A STUDY OF CHLORIDE CONTAMINATION IN THE OLENTANGY RIVER IN THE VICINITY OF COLUMBUS, OHIO

Mark Kuhlmann

INTRODUCTION

Purpose

The purpose of this paper was to determine if the Olentangy River was being contaminated by chlorides due to salting of streets and roads during the winter. Also, this study was to determine whether or not the amounts of chloride during the winter would be harmful to human beings, wildlife, or industry, or cause undesirable taste problems.

The area studied was a part of the Olentangy River Basin from Wilson Bridge Road, north of Worthington, Ohio, to Spring Street in Columbus, Ohio. This area comprises the lower 40 square miles of the basin. About 30 square miles of the area is within the boundaries of Columbus, and the remaining 10 square miles is in Worthington, Riverlea, or in open farmland. This area was divided into ten parts and a collection site was selected in each of them.

Background

Little work concerning chloride contamination has been done in this area, perhaps because the streams and rivers in Ohio generally have very low amounts of chlorides, usually less than 25 parts per million. The "Water Resources Data for Ohio, Part II, Water Quality Data", published by the United States Department of the Interior, gives data on considerably less than one tenth of Ohio's streams, concerning chlorides.

The United States Public Health Service (1962) has established a limit for drinking water for Interstate carrier's at 250 ppm of chloride. This level of chloride concentration is a maximum general limit for drinking water; concentrations greater than 250 ppm may give water a salty taste if sodium is also present. For some industrial uses, such as manufacturing stainless steel, water containing excessive chloride would have to undergo expensive treatment before it could be used. Also, large concentrations of chlorides may be corrosive to boat hulls and damage cooling systems of engines.

In Michigan more extensive study of chloride contamination has been done by Deutsch (1963). His paper, "Ground Water Contamination and Legal Controls in Michigan", deals with chloride contamination of ground water reservoirs due to salting streets during the winter. Deutsch reported another problem that occurs with street salting and deals with the use of chromates, which were added to the salt to reduce corrosion. The chromates were also contaminating water. Such corrosion inhibitors are no longer used.

Acknowledgements

Mr. Harold Brooks, an engineer with the Water Resources Division of the United States Geological Survey in Columbus, provided discharge data of the Olentangy River and also factors affecting stream flow.

Tom Carothers, a student in the Department of Geology gave assistance with the Hach water-quality analysis kit.

Bruce Hulman, an undergraduate Geology student, helped with the Argentometric chloride determinations.

METHODS OF INVESTIGATION

The methods used in this investigation took into account several pertinent factors:

(1) the geology of the area,

(2) the stream flow conditions, and

(3) the climatic conditions.

A discussion of these factors is presented in order to provide the proper basis for the study.

Geology of Study Area

This area lies in the region where Devonian limestone beds crop out. There are two major formations, the Delaware Limestone, a soft shaley limestone with many chert lenses, and the Columbus Limestone, a massive blue-gray unit. The Delaware Limestone ranges between 15 and 30 feet in thickness, and the Columbus Limestone is about 100 feet thick. The Delaware Limestone overlays the Columbus Limestone.

Overlying the limestone are two shale formations. The lower one, the Olentangy Shale, is a soft black unit about 30 feet thick. There are many limestone concretions in it, ranging in size from pebbles to small boulders. Above this unit is the Ohio Shale, a fissile, very dark shale about 35 feet thick. Some siliceous material can be found in this unit.

Above the bed rock is a layer of glacial drift. This layer averages 50 feet in thickness, although in some places it is not present. Just south of Stratford, Ohio, the limestone beds are exposed. Toward the north, near Powell, the drift is mostly poorly sorted with particle sizes ranging from silt to small boulders. At this place the drift is about 100 feet thick.

<u>Stream Flow</u>

In any water quality study, it is important to determine the quantity of water with which one is concerned. This is normally done by measuring the cross-section area of the river channel and using a velocity-meter to determine flow per unit of time. Unfortunately, the climatic conditions at the time of the tests precluded this technique, therefore another method was employed to attain some measure of discharge at the time of testing. The gage height of the river was recorded at sites 0 and 4 during the first test period. For the second test, the river was gaged until the heights were the same as during the first run and the second series of water samples were collected. Although the collecting of samples takes about 48 hours, the height did not vary significantly--only about two inches. The assumption was made that if the height of the river remains the same, the amount of water in the river would be the same because the cross-section would be constant.

This, however, is not always the case. The Olentangy River was undergoing some very significant channel changes at the time of testing. There are two major highway construction projects in progress, which have altered the channel. The construction also made it desirable for the river to be at the same height, so that coffer dams and forms for concrete would not be flooded.

The Delaware Reservoir, located just north of the city of Delaware, makes control of the river possible. By controlling the gates of the dam, the amount of water can be regulated to keep the water level in the river constant. This is important to the State Highway Department and it makes the task of measuring the flow of the river easier. The reservoir controls 397 of the river basin's 497 square miles, or 72 percent of the basin. Mr. Harold Brooks stated that this part of the river was under 100 percent controlled flow to help the road construction and to prevent flooding.

One additional factor affecting streamflow is the backwash or backwater from the Scioto River. Mr. Brooks estimated that this backwater extended up the Olentangy River as far as the Third Avenue bridge, and increases the stage of the river. Since this area is 22 miles from the Delaware Reservoir Dam, it cannot be easily controlled. This will cause some degree of error in the streamflow, but there was no convenient way to measure this error. There was also a slight error in the height of the stage (see Table I below), but the cumulative effect should still be small.

TABLE 1. RECORD OF GAUGE HEIGHTS ALONG OLENTANGY RIVER

Date	Site	Gauge Height
11 January 1969	Site 0	4 feet, 4 inches
11 January 1969	Site 4	5 feet, 2 inches
28 March 1969	Site 0	4 feet, 1 inch
29 March 1969	Site 4	4 feet, 11 inches

The flow-duration curve attached gives the stream-flow based on records taken from the past ten years.

The actual discharge was estimated to be between 900 and 1000 cubic feet per second, at site 0, and between 1000 and 1100 cubic feet per second at site 4.

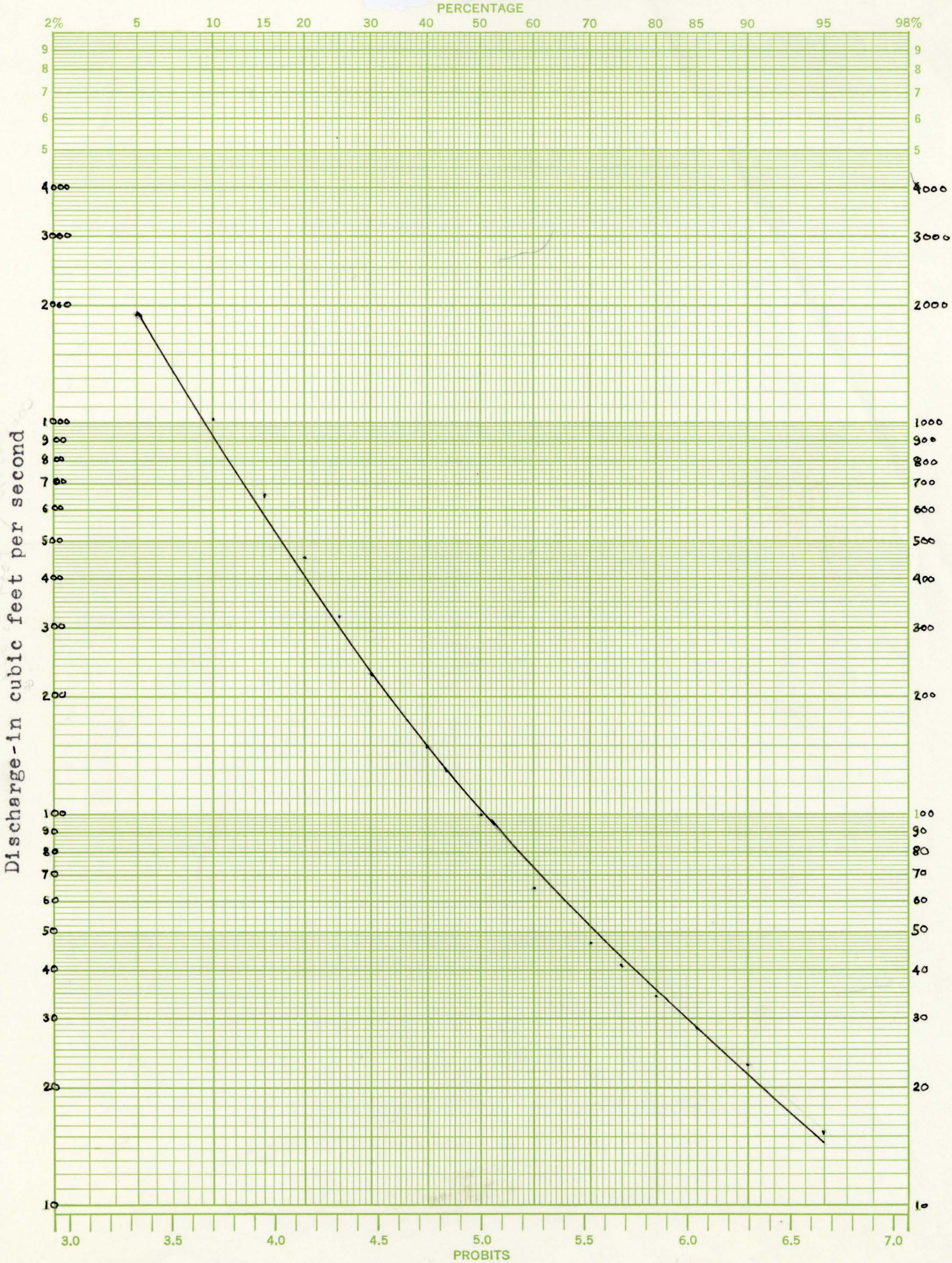
Climatic Conditions

The first set of water samples were collected on the 11th and 12th of January, 1969. During the two previous weeks 5½ inches of snow had fallen. On January 9th, a rainstorm added an additional ½ inch of precipitation that froze as a sheet of ice on the whole area. This almost stopped traffic. The city's street department, armed with 50,000 pounds of sodium chloride, plus calcium chloride, sand and cinders, managed to keep open most of the main streets. After two days and nights of toil, the street crews had the rest of the streets passable. The temperature had risen to 35 degrees and most of the storm sewers were flowing. The chloride concentration in a storm sewer on the Ohio State University campus was 460 ppm--this was at the point where it empties into the river. In Old Beechwold, none of the streets were cleared, and the sanitation sewer overflows were still frozen.

During the two weeks preceding the collecting of the second set of samples, the weather was more pleasant with daily highs in the forties and lows in the upper twenties. There were some snow flurries and a shower, but only 0.34 inches of precipitation was recorded. The Columbus area was 2.16 inches below normal for the year. The total precipitation was only 4.61 inches the 15th of March. By the end of March the deficit was 2.65 inches--only 4.95 inches of rainfall for the year.

Flow Duration curve for the Olentangy River north of Worthington. Gauging station 3-2268 -1955-65

FIGURE 1



This dry period must be the reason the river was at a slightly lower stage during the second test series.

Description of Collection

The following section gives a detailed description of the water collection areas. The figures for the area are rounded off to the nearest ¼ square mile. The roads are broken down into two categories, on the basis of use. First there are streets, which are two lane thoroughfares not designated state or federal routes, and second, highways, those state or federal routes that are main arteries for traffic, as well as four-lane streets (such as High Street). These are given to the nearest mile. The maps show the approximate areas drained by the river at that particular site. Because of construction and addition of new storm sewer lines, the maps are not completely accurate, but they give a good general indication of the area drained. Individual sites were selected above and below a major storm sewer in the area. This allows an indication of the amount of chloride entering the river from each area.

Site 0 - Location; Worthington, Ohio, just north of U. S. Route 161 at the west edge of Worthington High School campus (see Figure 2). The area drained is 6.75 square miles. There are 3 miles of 4-lane highways, 6 miles of 2-lane highways, and 17.5 miles of streets.

To the North - Mostly farmland, with a great deal of heavy underbrush and high grass (see Figure 2). At

Wilson bridge, the State Highway Department is constructing a new highway, I-270, has altered the river channel, and has torn up the area quite a bit. Worthingway, a new subdivision of about 300 houses, is located at the eastern bank of the river.

To the West - Mostly farmland, with a small group of houses at Linworth. Most of the farmland was fallow at this time.

To the East - Worthington, a city of 11,000 people, containing most of the streets in the area. There is an industrial park just east of the city.

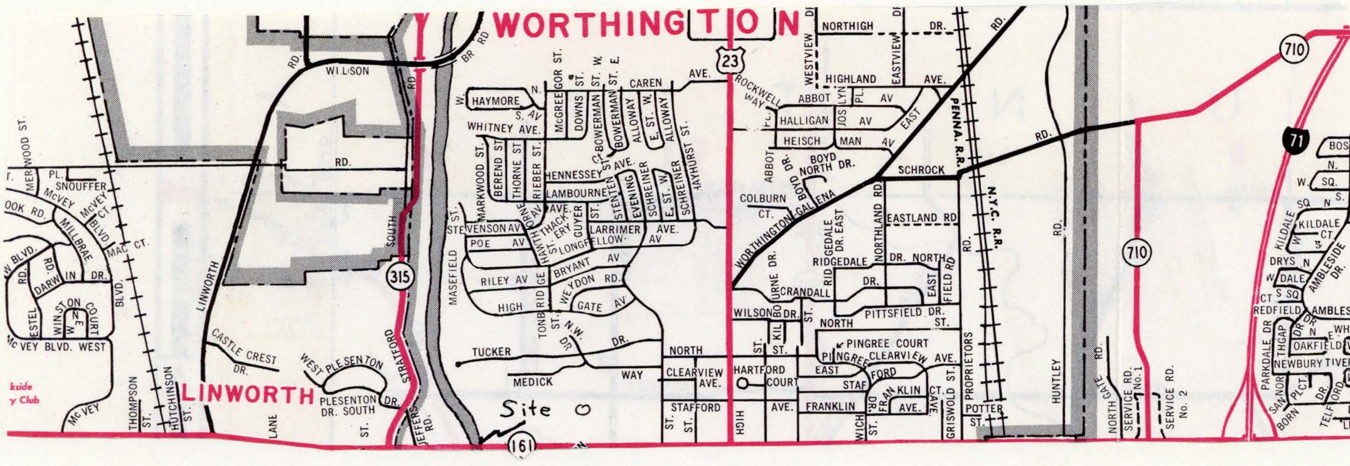


FIGURE 2. DRAINAGE AREA OF SITE 0

Site 1, 1A - Location; Riverlea, at the end of Fenway Avenue, and 50 yards downstream (see Figure 3). The area is 6.6 sq. miles. There are 4.5 miles of highways and 44 miles of streets, almost all of which are in Riverlea and Southern Worthington.

To the North - On the western bank, the area is scrub trees and brush. There is only one field of tilled ground and no housing. On the other bank is the village of Riverlea, with mostly large houses on large lots.

To the West - Mostly farmland, with the exception of Indian Hills, a suburban area of about 300 homes, the streets of which were not cleared at all during the winter.

To the East - Worthington and Columbus comprise most of this area. It is entirely urban, with 40 miles of streets and highways. These were well cleared and easily traveled.

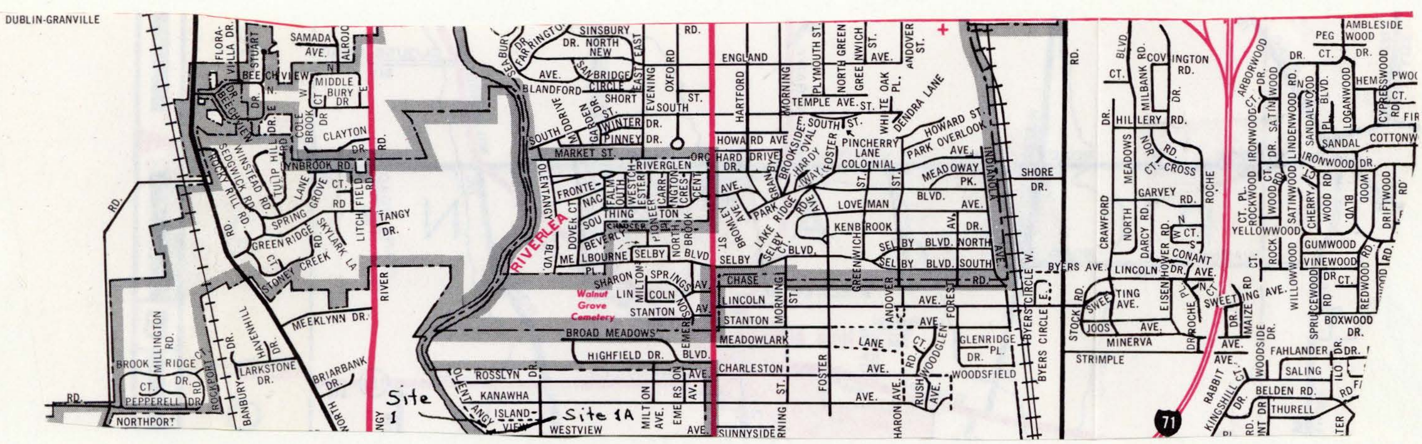


FIGURE 3. DRAINAGE AREA OF SITES I AND IA

Site 2, 2A - Location; Old Beechwold at Rustic Bridge Drive above and below a 72-inch diameter storm sewer that drains most of this community (see Figure 4). The area is 3.7 sq. miles and it contains 4.5 miles of streets.

To the North - The west bank of the river has mostly scrub trees and heavy brush along with an occasional small fallow field. There are a few islands in this area which are covered with brush and weeds. On the other bank is a large shopping center, with a 5 acre parking lot.

To the West - This area is about half residential and half untilled pastureland. The housing is not dense and there is considerable lawn area. The roads are narrow but well cleared. However, there are only about 4 miles of them.

To the East - This area was not touched by a snow removal crew. The streets were coated with a thin sheet of ice that made driving very hazardous. Further east, the conditions improved and the streets were well cleared.

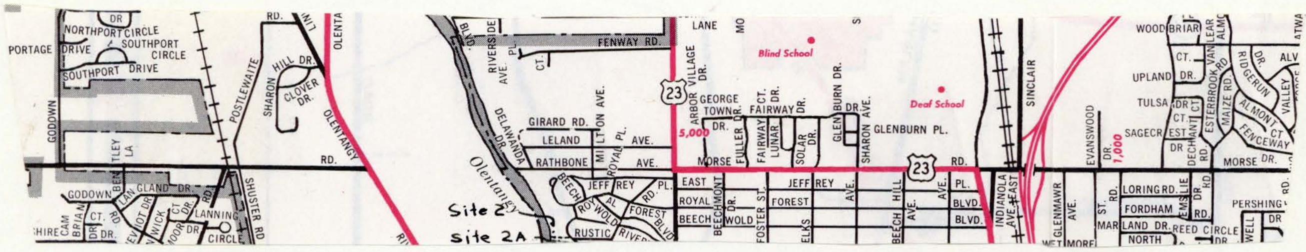


FIGURE 4. DRAINAGE AREA OF SITES 2 AND 2A

Site 3, 3A - Location; Whetstone High School, on the west side of the river above and below the pump house about 75 yards south of the Henderson Road Bridge (see Figure 5). The area is 3.6 sq. miles and contains 2.2 miles of highways and 14 miles of streets.

To the North - The area is all weeds and brush. The Eastern side of the flood plain is populated by New Beechwold, an urban area of 50 acres with well cleared streets (especially when compared with Old Beechwold).

To the West - This area is mostly fallow farmland with one major suburb, The Knolls. It is a densely built up area with streets that were not well cleared. The area's storm sewer is located along side of the pump house.

To the East - This is an urban area with streets that were not too clear, although main arteries were passable. There were a number of alleys that weren't counted as streets, which, however, had been cleared.

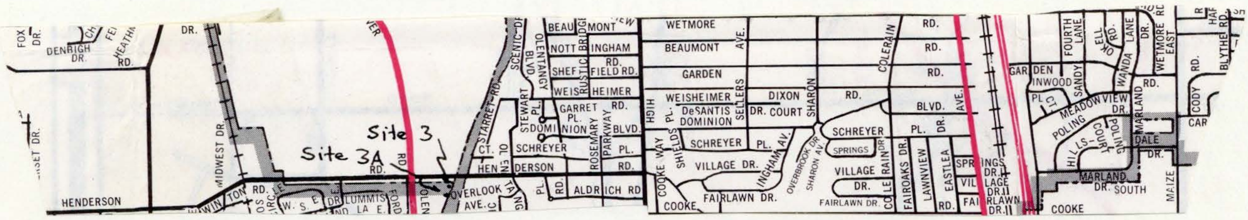


FIGURE 5. DRAINAGE AREA OF SITES 3 AND 3A

Site 4, 4A -- Location; Clintonville, at the West North Broadway bridge, and 30 yards below it (see Figure 6). The area drained is 6.1 sq. miles. There are 5.1 miles of highways, mostly 4-lane, and 41 miles of streets. There are also many alleys.

To the North - On the west side of the floodplain is a mowed field and the Olentangy River Road. There are also a few houses. On the east side the area is half parkland and half residential area.

To the West - This area is mostly residential, although not as built-up as city sections. The main streets were well cleared, but the side streets were almost untouched.

To the East - This area is a densely populated region with about two-thirds of the streets and about three-fourths of the houses of the total area. Both the main and side streets were fairly clear.

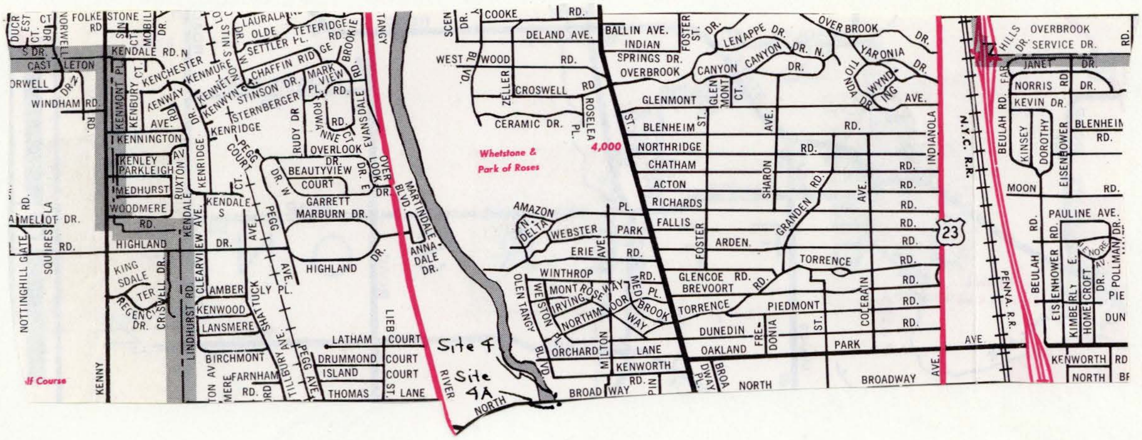


FIGURE 6. DRAINAGE AREA OF SITES 4 AND 4A

Site 5, 5A - Location; Dodridge Street Bridge and 50 yards above the bridge (see Figure 7). There are two 36 inch diameter storm sewers that enter the river at this point. The area is 3.8 square miles and has 7 miles of highways and 38 miles of streets.

To the North - This area is mostly brush and scrub trees and has only a few houses. There are, however, a number of very small drainlines 4 to 6 inches and 2 sanitary sewer overflow lines. The sanitary lines were frozen at the time of the first collection.

To the West - The Union Cemetary is the largest single feature of this area. It comprises almost 35 acres of lawn, along with several buildings and a mile of road. Further west is Upper Arlington, a suburban type of city with large lots and wide, well cleared streets.

To the East - This area is part of Northern Columbus and is typically urban, with many streets that were fairly clear. About three-fourths of the total street milage is in this area.

FIGURE 7. DRAINAGE AREA OF SITES 5 AND 5A

Site 6, 6A - Location; Lane Avenue Bridge and 20 yards below it (see Figure 8). The area enclosed is 2.55 square miles. There are 7.5 miles of highways and 12 miles of streets.

To the North - This area is mostly brush and scrub trees, with a few apartment buildings on the east bank of the river. An alley parallels the course of the river, but it remained impassable during both collecting periods. On the other bank is the Union Cemetary, which is almost entirely lawn.

To the West - Most of this area belongs to the University Farms, and with the exception of a few unpaved service roads, there is nothing but farmland. At this time, this area is mostly in pasture.

To the East - This area is urban, and is composed mostly of narrow streets, which were only partially cleared during the first collection period.

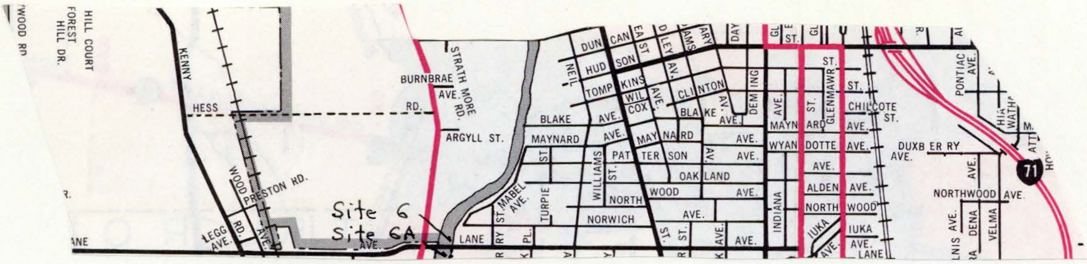


FIGURE 8. DRAINAGE AREA OF SITES 6 AND 6A

Sites 7, 7A, and 8 - Location; The Ohio State University Sites 7 and 7A are above and below a 96-inch diameter storm sewer (see Figure 9). Site 8 is about 100 yards below the McCracken Powerplant outlet. The area is 3.1 sq. miles and has 8 miles of highways and 13.5 miles of streets.

To the North - This area currently has considerable construction in progress--the site of the new University College. Most of this area has been cleared of vegetation, due to the building activity.

To the West - This is University Farm land, along with the Veterinary Experiment Station and some agricultural buildings. This area is also pastureland, but there are a few paved service roads, also.

To the East - The Ohio State University main campus, a 90-acre area that was heavily salted, and which contains more than 15 acres of cleared parking lots. It has many sidewalks, which were cleared and salted this winter.

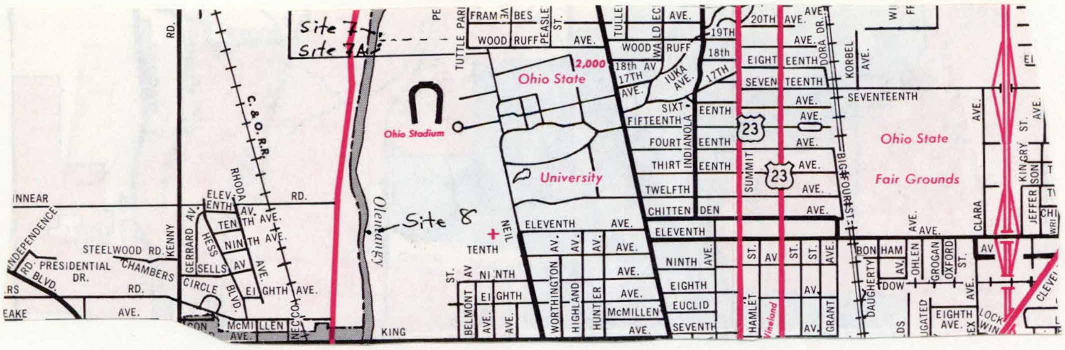


FIGURE 9. DRAINAGE AREA OF SITES 7, 7A, AND 8

Sites 9, 9A, and 10 - Location; King Avenue Bridge and 200 yards below it (see Figure 10). Site 10 is at the Spring Street Bridge. The area contains 4.5 sq. miles, and 39 miles of streets and 24 miles of highways. There are levees on both sides of the river.

To the North - This area contains the University's practice fields and hospital. On the other side is a parking lot.

To the East - Battelle Memorial Institute is located directly east of the river, with a large parking lot. Further east is Columbus's near north side, an area of low income housing with poor streets.

To the West - This area is about equally divided between light industrial and residential buildings. The Olentangy Freeway is being constructed in and near the river channel.

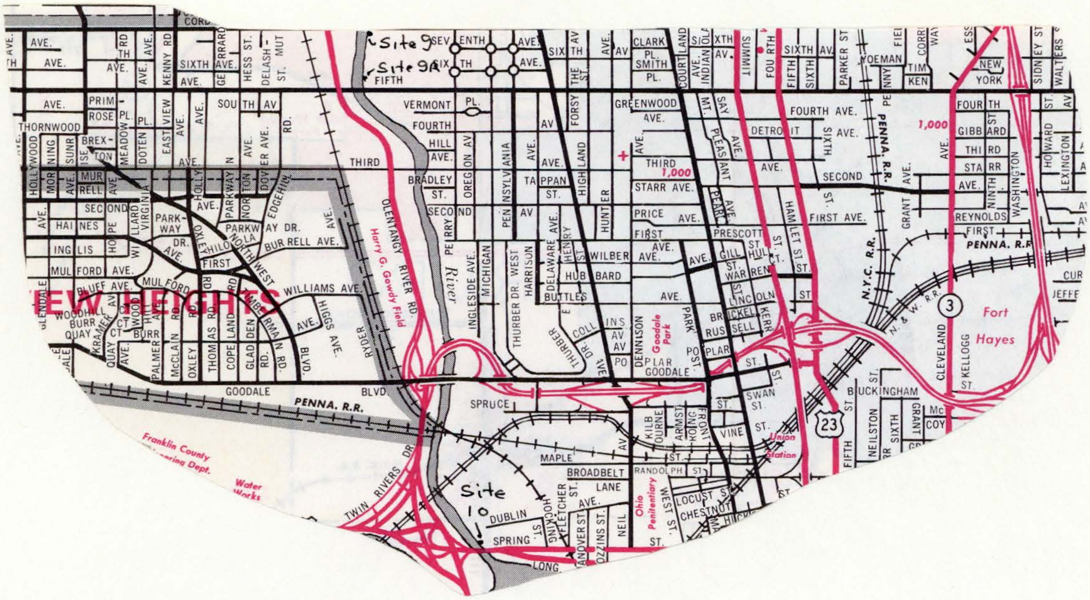
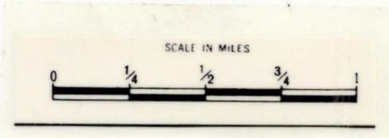


FIGURE 10. DRAINAGE AREA OF SITES 9, 9A, AND 10



Testing Procedure

Samples of river water were collected at each of the sites. About one pint of water was collected in quart polyethylene freezer boxes. The temperature was measured at the time of collection. The samples were collected as close to the same time as possible to minimize changes in climate that might affect the water quality or streamflow. Factors such as precipitation might alter the concentration of chloride in the river, owing to dilution.

The water samples were tested for chloride using the Argentormetric method (titration method). This test uses silver nitrate, which reacts with sodium chloride to form silver chloride and sodium nitrate. A potassium chromate solution is used as an indicator.

The silver nitrate used in the tests was 0.0141 normality at the beginning. However, silver nitrate is not a very stable compound, and the normality varies due to exposure to light and age. Therefore, the normality was checked before each testing period. This done by titrating the silver nitrate into a sodium chloride solution of a 0.141 normality, and the ratio of silver nitrate to sodium chloride multiplied by 0.0141 gives the true normality of the silver nitrate solution. This varied between o.0121 N and 0.0129 N.

After checking the normality of the silver nitrate, the amount of dilution before the indicator solution turned color (this depends upon the size of the test sample) was determined by titrating a sample of distilled water of the same volume as the test sample.

The formula for calculating the concentration of chloride is:

$$Cl^- = \frac{(A-B) \times N \times 35450}{\text{ml of sample}}$$

Where A = amount ml of silver nitrate titrated in to the sample when the endpoint of the silver nitrate-sodium chloride reaction was reached,

Where B = amount of silver nitrate ml titrated in to the distilled water sample when the indicator turned color, and

Where N = normality of the silver nitrate solution.

The Hach testing apparatus was also tried, but this test proved to be of little value. (The error was quite high with samples of relatively low chloride concentration.)

The Hach Coliform Test Kit was used in both test runs to determine presence of Coliform Bacteria.

RESULTS

This investigation was intended to show the effect of road salting and resulting chloride contamination in the Olentangy River Basin in the Columbus area. It was observed that:

(1) The chloride content showed a 78 percent increase after salting due to runoff from a severe ice storm.

(2) Temperature observations showed significant increase in the vicinity of the Ohio State University power plant.

(3) Coliform bacteria were found only in the second series of tests.

The argentometric chloride determination test showed the chloride content of the water increased 78 percent after runoff from a severe ice storm. The mean chloride content was 41.0 ppm at this time, while the test during good weather showed a mean chloride content of 23.1 ppm.

The temperature of the water remained relatively constant during both test series, except for a significant increase in the Ohio State University area. The McCracken Power Plant is the source of this increase. It pumps the water used for cooling into the Olentangy River. An operator at the plant said that 6000 gallons per minute was pumped into the river at temperatures between 80 and 110 degrees F.

Coliform bacteria tests performed on samples of water from sites 2, 5, and 9, showed the bacteria to be present only in the second test run. In the first run the tests were negative. Coliform bacteria are usually an indication of sewage pollution. Site 0 has the lowest chloride concentration of any sites checked in the area. The map shows the chloride concentration in the river during the first trial.

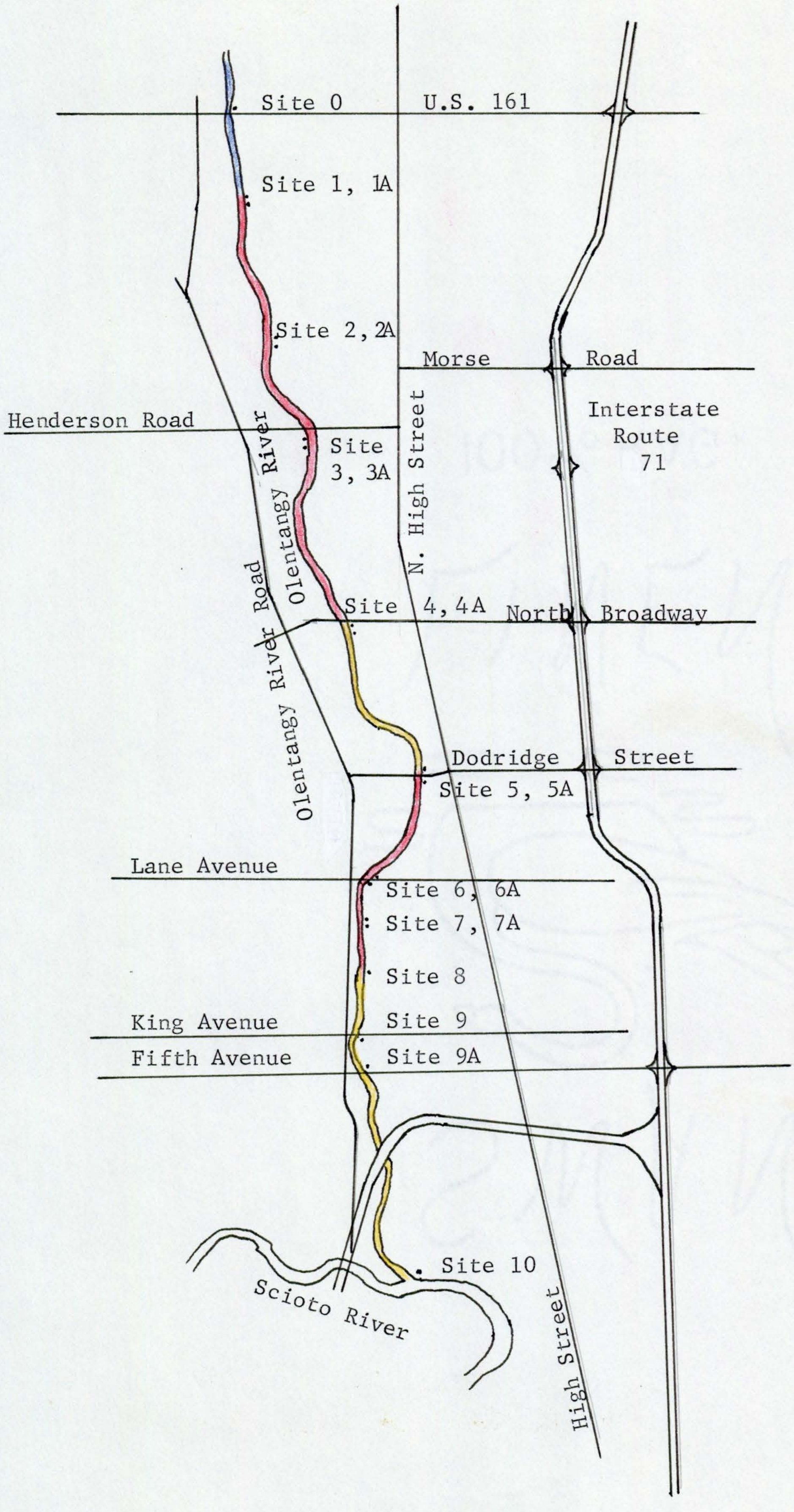


FIGURE 12.

Basin Map
Showing Chloride
Concentration
After An
Ice Storm

January 26-29, 1969

KEY

Areas of low chloride concentration 0-20 ppm

Areas of moderate chloride concentration 20-40 ppm

Areas of High chloride concentration 40+ ppm

TABLE 2. TABLE OF CHLORIDE CONCENTRATION AND TEMPERATURE VALUES

Site of Observation	Trial #1 Chloride ppm	Trial #1 Temperature, ^{o}F	Trial #2 Chloride ppm	Trial #2 Temperature, ^{o}F
Site 0	11.5	33^{o}	19.6	46^{o}
Site 1	46.5	32^{o}	26.7	44^{o}
Site 1a	46.5	32^{o}	26.7	44^{o}
Site 2	42.0	32^{o}	24.0	43^{o}
Site 2a	46.0	33.5^{o}	23.0	43.5^{o}
Site 3	44.0	32^{o}	20.8	43.5^{o}
Site 3a	44.3	32^{o}	21.4	43^{o}
Site 4	36.5	32.5^{o}	20.1	44.5^{o}
Site 4a	37.1	33^{o}	20.4	44.5^{o}
Site 5	43.1	33^{o}	20.5	44^{o}
Site 5a	44.0	33^{o}	20.5	44^{o}
Site 6	46.0	33^{o}	22.0	44^{o}
Site 6a			22.4	44^{o}
Site 7	47.0	33^{o}	22.5	45^{o}
Site 7a	51.0	33^{o}	31.0	45^{o}
Site 8	51.1	48^{o}	26.5	64^{o}
Site 9	30.5	34^{o}	24.5	45^{o}
Site 9a	31.0	34^{o}	24.0	45^{o}
Site 10	39.1	35^{o}	23.8	43^{o}

FIGURE 13. GRAPH OF CHLORIDE CONCENTRATION AFTER SEVERE ICE STORM

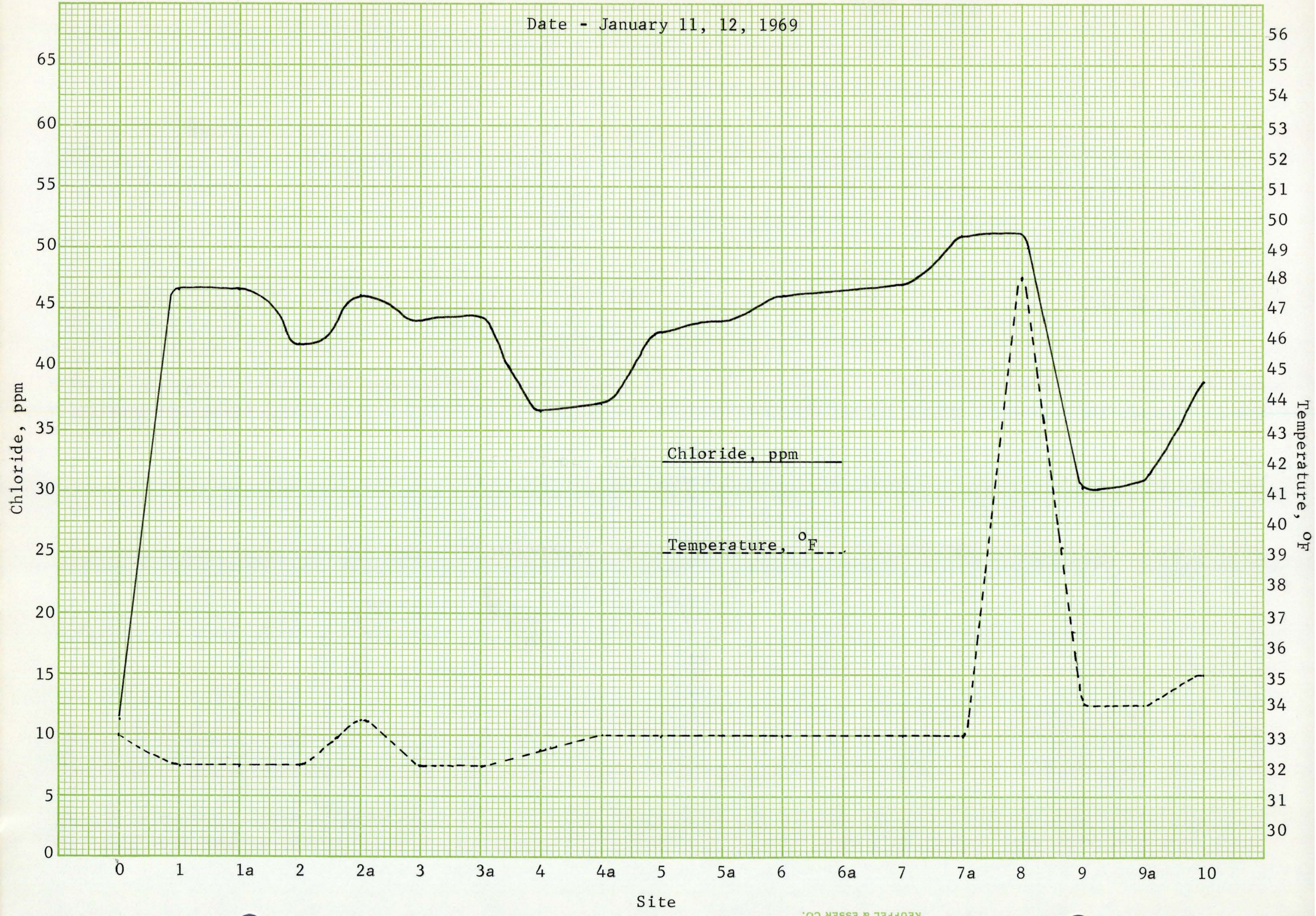
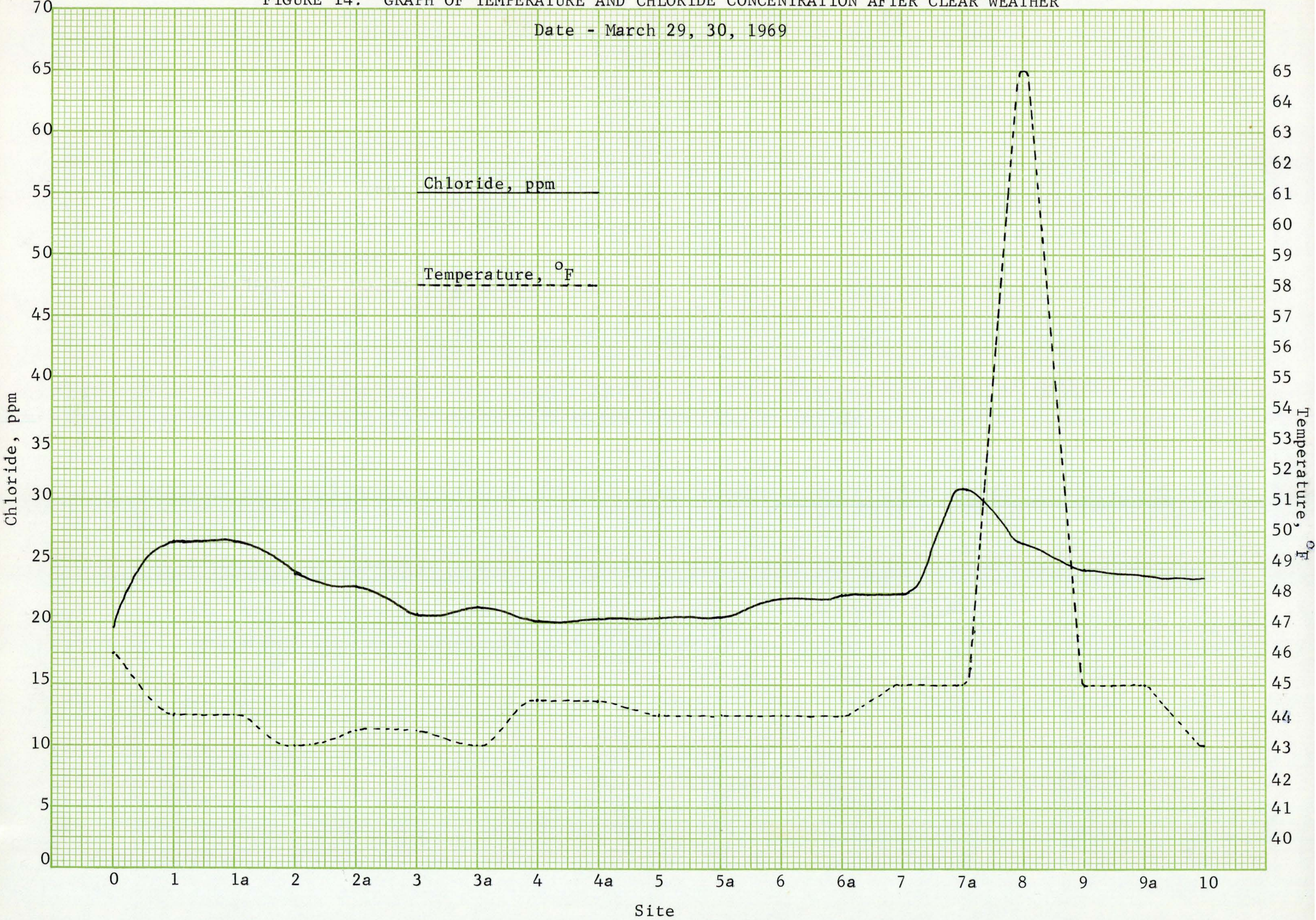


FIGURE 14. GRAPH OF TEMPERATURE AND CHLORIDE CONCENTRATION AFTER CLEAR WEATHER

Date - March 29, 30, 1969



CONCLUSIONS

The results of the chloride tests were expected and seem reasonable. The absence of high concentrations of chloride (the highest percentage recorded was 51.6 ppm), indicates that corrective measures would not be warranted in most instances. For some industrial uses, the level of chloride might have to be reduced, but the chloride would not present a problem for most uses.

Thermal pollution probably presents a greater problem. When an increase in temperature as high as that found in the Ohio State University area is recorded, some effect will almost certainly occur to the ecology of the river. Because the oservations were made only on the banks of the river the total effect to the area is not known. More research is needed in this area.

The coliform bacteria found in samples of the second run are an indication that the river is being polluted by sewage. These tests do not indicate the quantity of bacteria, but only its presence. Further study of this problem should be made, because of the harmful effect of this bacteria on human beings when the concentration is sufficiently high. This is a potential problem, because water of Olentangy River is being used for human consumption, but it is treated.

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